SOME FACTS ABOUT THE GENERAL SCIENCE SITUATION

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It may be assumed, at the beginning of any discussion upon the subject of general science, that its advocates and its opponents are equally impressed with the importance of science in any educational scheme. Teachers of science owe a distinct debt to Professor Coulter for the incomparable manner in which he has emphasized this importance.[1] His classic addresses should be familiar to every teacher of science and to the administrative officers of our American high schools.

It is in fact this very interest in science instruction and appreciation of its unique mission which make it impossible for many teachers in high schools to view the present situation with complacency. In 1908 the same author stated:

> I may be allowed to say, as the result of many years of experience, that this average college preparation presents to the universities the most narrow and unevenly trained material that can be imagined. Nowhere are the evils of specialization so apparent as in the entrance preparation demanded by many colleges. If this specialization results in comparatively poor college material, its results may be regarded as simply disastrous to the high school in its primary purpose.[2]

This statement, made by a scientific man, may be taken to represent the conditions in the sciences along with other subjects, as the conditions existed at that date. There has been no revolution in the high school since that time sufficient to invalidate the criticism.

The case cannot be allowed to rest with a criticism of science instruction along with that in other branches; it suffers more in

[1] "The Mission of Science in Education: An Address." Published by the University of Michigan, 1900. See also same title, *School Review*, XXIII, 1–8, January, 1915, and *School Science and Mathematics*, XV, 93–100.

[2] "What the University Expects of the Secondary School," *School Review*, XVII, 81, 82.

contrast with them. Data published by the United States Commissioner of Education and referred to by Professor Barber in the preceding number of this journal[1] indicate that the special sciences are in general not holding their own in the high schools, and that they are almost alone in this decrease. Such a condition of affairs in a predominantly scientific age is sufficiently startling. There are possible criticisms of the validity of the statistics which give ground for hoping that the situation is not so bad as it appears, but on the other hand there are confirmatory figures[2] which indicate that the actual situation is far from reassuring. In the state of Connecticut, which may be taken to represent a rather conservative situation, there were in 1910–11 but 6,896 enrolments in science out of a total of 79,172 enrolments in all subjects.[3] In the middle western state of Ohio during a recent five-year period for which data are available, notwithstanding an increase in high-school enrolment of approximately 22 per cent there was a gain of but 5 per cent for the older sciences, as appears in the enrolment figures given in Table I.[4]

TABLE I

	1909	1913	Change
Botany	13,373	14,519	+1,146
Physics	13,094	12,979	− 115
Chemistry	3,980	5,960	+1,980
Physical geography	23,544	23,344	− 300
			+2,711

A partial explanation of the situation, but one wholly devoid of comfort to the advocate of science instruction along established lines, may be found in the growth of agriculture in Ohio. The enrolments in this subject increased from 1,560 in 1909 to 118,333 in 1913. Such extremely unsatisfactory conditions demand both consideration and action on the part of those who are convinced that

[1] *School Review*, XXIII, 11.

[2] See discussion of the data by Downing, "The Scientific Trend in Secondary Schools," *Science*, N.S., XLI, 232–35.

[3] Report of the Board of Education of Connecticut, 1910–11.

[4] Data from Ohio School Report, 1913.

science has a mission in education, if science is to be preserved for the majority of the pupils who are affected by our educational organization.

Essential agreement as to the results which science should accomplish for us in education has not brought agreement as to methods. The methods are conditioned upon many factors. Among these are, not only the final result which it is desired to achieve, but also the nature of the pupil in whom the results must be produced and the character of the institution which is the instrument in the process. These latter two factors have not always been comprehended by those who have discussed science instruction in the high school. It should be kept in mind that the field of secondary education is a special field, which is just as clearly delimited from its co-ordinate fields of elementary and college education and from the correlative departments of advanced instruction which deal with the subject-matter of the sciences as are the sciences from each other.

Failure to understand the secondary-school pupil often results in presentation of a plan of work which is ill adapted to him. The writer has been interested in examining in some detail a high-school textbook which is very largely used in the first year of the high school, written by an author who has not entered publicly into the discussion of the general science movement. It happens that the author has written also a comprehensive college book upon the same subject. One expects to find here a clear recognition of the difference in maturity and mentality between a ninth-grade pupil and a college student. Comparison of the two books reveals that every chapter in the college book, save one, is present in the high-school book either as a chapter or as a subdivision of a chapter, and headings are almost identical. In two chapters which were selected at random for more detailed examination it was found that every section but two in the college book reappeared in the high-school book, usually under identical caption and in the same order, but occasionally as paragraphs added to the nearest related section. Even the diction is similar, and in many cases whole sentences are identical. It is not often that such direct comparison can be made, but all high-school teachers will recognize

that many textbooks and many educational articles carry the point of view of the mature mind as clearly as does this book. These are usually good books, and would serve admirably for the instruction of a pupil with the type of mind for which the authors wrote the books. Unfortunately the type does not exist in at least the earlier years of the high school. Similar misapprehension of the pupil colors much of the current educational literature.

No less confusing are the results of failure on the part of writers to command the facts about the high school as an institution. It must not be forgotten that the present high school is a unique institution and one of very late growth. The high school of today is a very different thing from that of a decade ago and bears only a remote resemblance to the school of the eighties. Many of the arguments directed against general science would not be presented if the obvious scientific procedure of first securing the facts about the high school were employed.

The question of teachers for general science courses will serve as well as any for illustration, since some of the elements of the problem are readily reduced to quantitative statement. It is asserted in many quarters that it is wholly impossible to secure teachers for a subject so broad as general science. The contrast is made with special sciences, each taught by an instructor who is a specialist in his subject and who devotes his whole time and energy to it. Many students of education would feel that there is at least room for argument as to whether a teacher with the narrow range of interest and training indicated is likely to be the best instructor of youth. Granting that he is, a very attractive picture of ideal conditions can be drawn. The difficulty is that the high school whose practical administration allows of an organization of specialists is an extremely rare phenomenon. The writer pointed out in the pages of this *Journal*[1] that in 1912 approximately 89 per cent of the teachers of first-year science in Illinois were instructing in at least three subjects, while as many as 40 per cent had no fewer than five subjects. More complete data have been available at any time.

In the current issue of the *Illinois School Directory*,[2] issued from the office of the superintendent of public instruction, are

[1] "First-Year Science in Illinois High Schools," *School Review*, XXI, 546.

[2] *Illinois School Directory*, 1914–15, Circular 81, Springfield, 1914.

listed 507 operating township and city four-year high schools. The reports from 63 of these are incomplete and could not be used in the summaries given below, but only one of the missing schools is of sufficient size to be of importance. Where the report is complete, the *Directory* gives for each high school the name of each teacher with the subjects taught. The accompanying tabulation (Tables II, III, IV) exhibits the distribution of science teachers among the various subjects. Supervision is counted as an additional subject in the case of the few administrative officers who are listed as teaching a single subject. Biology is counted as two subjects since it undoubtedly usually represents separate courses in botany and zoölogy. In either of these cases the number of teachers involved is too small greatly to influence the totals.

TABLE II

DISTRIBUTION OF TEACHERS AMONG COMBINATIONS OF SCIENCE AND NON-SCIENCE SUBJECTS TAUGHT*

NUMBER OF SCIENCES	NUMBER OF NON-SCIENCE SUBJECTS						TOTAL
	0	1	2	3	4	5 or More	
1 Science	116	101	56	23	10	2	308
2 Sciences	35	39	20	10	4	.....	108
3 Sciences	5	7	3	4	1	.....	20
4 Sciences	3	3	1	1	.....	.....	8
Science	123	178	60	7	8	1	377
Biology	36	.....	.....	.....	.....	.....	36
Total teachers							857

*Figures in table indicate number of teachers in the group teaching the number of sciences indicated at the left-hand end of the line in combination with the number of non-science subjects indicated at the top of the column.

TABLE III

DISTRIBUTION OF 116 SPECIAL TEACHERS OF ONE SCIENCE ONLY

Physics	31
Chemistry	23
Geography	27
Botany	5
Zoölogy	9
Physiology	14
Agriculture	4
Total teachers	116

TABLE IV

SUMMARY OF DISTRIBUTION OF TEACHERS BY SUBJECTS

High schools represented	444
Total number of teachers represented	857
Total instructing in two or more subjects	741
Total instructing in one subject only	116
Percentage instructing in one subject only	13.53
Total science teachers in city of Chicago	134
Total instructing in two or more subjects	63
Total instructing in one subject only	71
Percentage instructing in one subject only	52.98
Total science teachers outside of Chicago	723
Total instructing in two or more subjects	561
Total instructing in one subject only	45
Percentage instructing in one subject only	6.22

The data presented in Tables II–IV show that in the state of Illinois only 13.53 per cent of the teachers of science are able to restrict themselves to a single subject. If we eliminate the city of Chicago from consideration, the proportion falls to the strikingly small proportion of 6.22 per cent. This latter figure doubtless more nearly represents conditions in all those states in which a large city is not a part of the situation. Even if we include in the calculation the biology teachers and all other cases in which the instructor is assigned two sciences only, the percentage for the whole state is increased only to 21.8 and for the portion outside of Chicago, to 13.1. There are but six schools in the state in which all the science teachers are able to restrict themselves to a single subject. The vision of schools with faculties made up of specialists may well be laid away along with other notions which lie outside the region of practical affairs.

The condition discussed above is not the result of poor administration, nor is it peculiar to this state. The tabulation of the schools of Illinois according to size (Table V) shows that there are few large schools.

Administrative officers agree that it is not possible to secure a well-differentiated departmental organization with a school of fewer than 500 pupils; ordinarily it is not accomplished in a school

of fewer than 1,000 pupils. As a matter of fact, there are in Illinois no schools of fewer than 600 pupils which have as many as five science teachers. Accepting 500 as the line of division, there are in the state 36 schools in which teaching by specialists is possible if the curriculum includes only a limited number of sciences, and 13 schools in which it is probable. The total number of teachers involved is 181 in the former case and 114 in the latter.

TABLE V

SUMMARY OF 444 HIGH SCHOOLS OF ILLINOIS BY SIZE

Size not given	6
Less than 100 pupils	259
100–199	94
200–299	26
300–399	18
400–499	5
500–999	23
1,000 or more	13
Total	444

This abundance of small schools is not a condition peculiar to Illinois; rather it appears to be characteristic of the high-school situation generally. No data are available covering all the high schools of the country in detail, but certain studies of representative groups have been made. Jessup and Coffman have reported upon the schools of the North Central Association of Colleges and Secondary Schools.[1] The 667 schools in this association are distributed through eleven states. They have been admitted to the organization on the basis of efficiency and may therefore be taken to average somewhat above the mean for the North Central states. The following data are taken from the tabulations and summaries:

Median school enrolment by states, 112 to 244 pupils.

Median enrolment by cities, above 500 only in cities with population above 50,000.

Total number of schools with enrolment below 500 is 571.

Total number of schools with more than 20 teachers, 99.

Median number of teachers, by states 5–10.

It will be noted that the small size of schools and the small number of teachers are characteristic of this rather broadly

[1] "North Central High Schools," *Thirteenth Yearbook of the National Society for the Study of Education*, 1914, Part I, pp. 73–115.

distributed group of selected schools just as they are of the unselected group studied in the state of Illinois.

Jessup has also shown for the state of Iowa,[1] on the basis of a study of 200 schools, that but 19 per cent of all teachers are instructing in one subject only. In the sciences the largest proportion of special teachers is found in the subject of physics where one teacher in a hundred is teaching physics alone.

It is obvious that it is not possible to gain from the rather extended data available the notion that the high school affords opportunity to any considerable number of special teachers. It would appear, therefore, that those who base their recommendations upon an organization with highly specialized teachers have not been in possession of certain essential facts which are evident to those who are familiar with the high schools.

That there is a problem relative to securing teachers for general science, just as there is a problem with reference to all science teachers, is recognized. It may be noted from the foregoing tables that very much the largest number of teachers are engaged in teaching science without limitation as to department and frequently with other subjects added. The major technical qualifications for which administrative officers must look, therefore, are knowledge of the subject-matter of science in general and ability to teach, and these are important qualifications for the general science teacher as well. The problem arises from the fact that the only institution which is in position to supply the needed teachers has not faced the facts. In spite of the fact that the high schools are equipped almost exclusively with college-trained teachers and that the colleges encourage their graduates to seek such positions, most college instructors in science appear to cherish the delusion that they are training special teachers. When the colleges come to insist upon greater breadth on the part of prospective teachers and require professional preparation as a prerequisite to their own recommendation to teaching positions, much progress will have been made with the problem of preparation of science teachers.

Another important fact regarding the high school as an institution is that the science curriculum has never been reduced to

[1] "Specialization in High School Teaching," *Midland Schools*, XXVIII, 169–71.

coherence. Investigations by Hunter, Weckel, and Caldwell, lately reviewed and extended by Downing,[1] have shown that the usual sciences may occur in almost any conceivable sequence. If data were included representing the remainder of the sixteen or more sciences and quasi-sciences now represented in the high schools, confusion would be worse confounded. Professor Barber, in his paper in the January number of the *School Review* (p. 20), pointed out that the same uncertainty rules in the arrangement of subject-matter within the sciences. Certain general tendencies may be discerned, but nothing more definite. General science is not an interloper, disturbing a satisfactory and established order of things. Rather, it has been shown that enrolment in science is commonly greater in three years following general science than in four years without it.

General science is the first step in an attempt to secure some sort of order and sequence worthy that discipline which has been supposed to be the synonym of organization. It attacks the problem at the logical point of beginning, the first year, and by the only method that ought to appeal to scientific men—experiment. General science is frankly experimental, but it is not a random or uncontrolled experiment. It has been designed by those who are in the schoolroom and know the situation, and the final decision will be made upon the evidence presented by the high-school teachers of the country and on the basis of classroom results. It is therefore wholly independent of the a priori judgments of those who are not in contact with first-year pupils or have not come into relation with the experiment in the classroom. This experiment, like any other scientific investigation, requires first-hand contact with materials. At the present moment, general science lays claim to the consideration of educators as the only constructive proposal for the reform of the secondary science curriculum, resting upon an experimental basis.

The ideal of general science has not been better expressed than in the words of the author who was quoted in an earlier part of this paper.

[1] "Some Data regarding the Teaching of Zoölogy in Secondary Schools," *School Science and Mathematics*, XV, 36–43, January, 1915.

A minimum of subjects and a maximum of time, continuous rather than scattered work, a range broad enough to touch upon all of the fundamental regions of work, methods that will secure precision in thought and expression, contact with the life and work of the times in which we are destined to live, are certainly principles that are sufficient, but concerning whose details none should dogmatize, for they may well vary with the teachers and with the local conditions.[1]

General science proposes to be continuous and coherent throughout the year instead of dividing the time between two or more sciences; it is continuous with the later sciences and affords a bond of union between them; it is continuous with the experiences of life. It is broad enough to touch all fields of science and to allow the use of the scientific method as it is expressed in life. It is in relation with the life that the pupils are now leading and with that which they are about to enter as they leave school.

General science takes the pupil as it finds him in reality, usually with little acquaintance with science and scientific habits of thought, and attempts to turn him over at the end of the year with something of both. Because the first-year pupil is neither capable of extensive abstraction nor interested in the philosophical generalizations of science, the course deals with materials which have not been abstracted from the relations in which the pupil knows them, and it proceeds by analysis of the phenomena toward final abstraction and generalization. A general science course is not synthetic in the sense of composing a whole from its elements; rather it is analytical since it deals with an environment which is already composed and attempts to resolve at least some of its elements. Perhaps the course might better be called integral.

Since facts are the groundwork of science, any science study must be informational, and a very large amount of information is defensible in a first-year course. At this time the pupil is yet in the stage where a large part of his attention is absorbed in getting acquainted with his immediate environment. So long as the facts are related to the real world in which he lives rather than to a philosophical abstraction, they and the principles developed in connection with them become a part of the mental furniture of the

[1] Coulter, "What the University Expects of the Secondary Schools," *School Review*, XVII, 82.

individual, ready to be applied to the solution of problems arising out of new situations. Dissociate the facts from their real setting and they are only so much information which is less than encyclopedic because it is not alphabetized and available. The writer is sure that he appeals to the experience of many others than himself when he selects as an example the common high-school courses in plant morphology and evolution. The principles involved are too abstruse for the ninth-grade child and the facts are remote from any concrete connections. The weaker students and the more independent ones give it up as hopeless; the more faithful and docile ones learn the material by rote. It would be difficult to imagine a more barren example of encyclopedic information without even the saving grace of remote usefulness. The encyclopedic will be found in any course which carries too much the point of view of the mature mind, whether called special science or general science, for the framework of principles which binds such a course together is beyond the grasp of the adolescent child. Failing the principles, there is nothing for the pupil to get but unrelated facts.

Those who are engaged in teaching courses in general science and in developing such courses to fit the needs of their pupils are not trying to provide the pupils with unattached information; but they believe that from the phenomena of nature there may be chosen a group of phenomena that are closer to the actualities of adolescent life than those commonly used, while at the same time these materials may be equally educative. They believe that these materials can be organized in a manner that will relate them on one side to the mental processes of the pupils as they come to the high school and on the other to the more special and philosophical organization of later instruction and to life outside of school. The present types of organization in general science, as in special science, are not perfect. It is expected that investigation and experience will modify this organization as they are doing with all the subjects in the curriculum. To this end general science invites keen and frank criticism from all those who are in contact with the experiment at any of the hundreds of places where it is in progress.